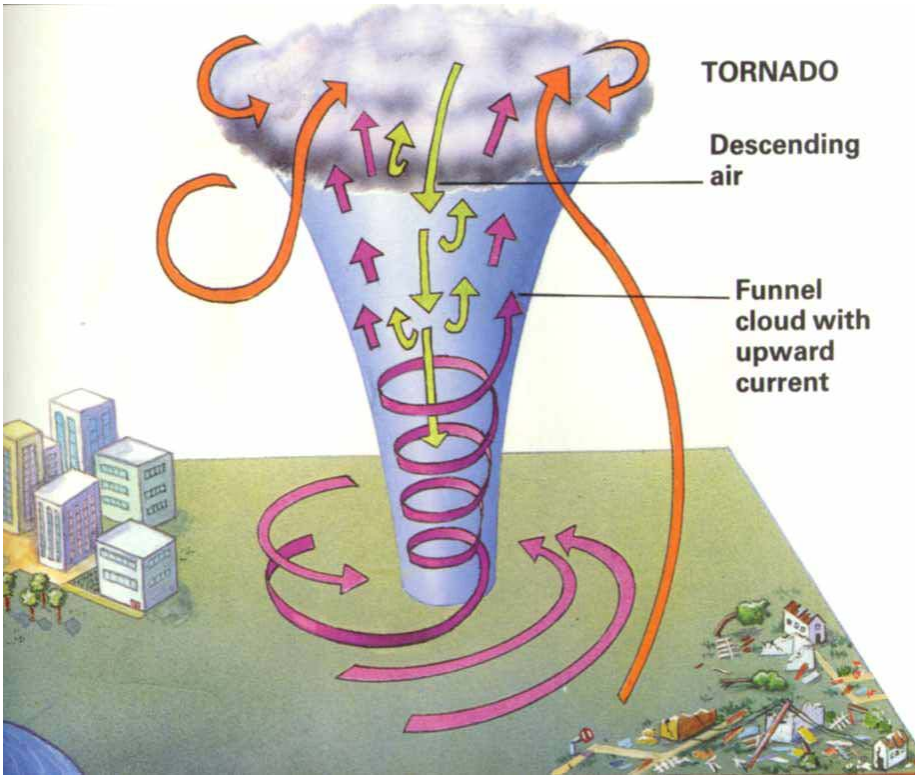
More information about tornadoes:

Tornadoes are by-products of severe thunderstorms, and National Weather Service watches and warnings for thunderstorms often precede or coincide with tornado alerts.

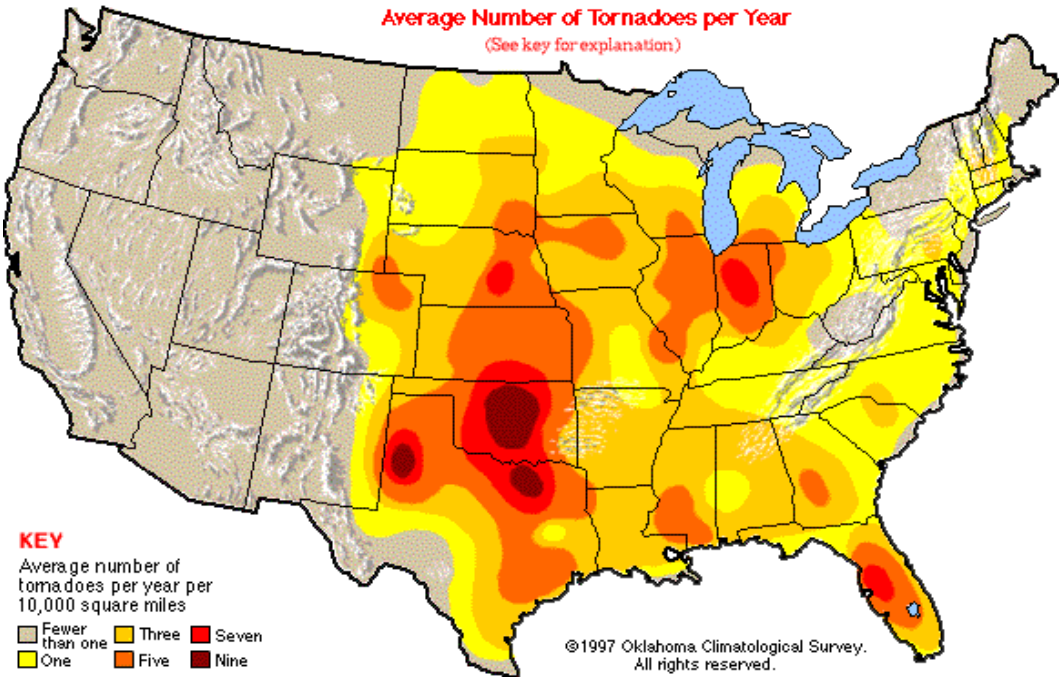
A typical tornado is a tall, funnel-shaped whirlwind of cloud up to 2,000 feet high. In some cases, though, the funnel may be virtually invisible.

In the middle of the tornado is an eye of descending air, surrounded by a strong upward current that sucks up or destroys everything in its path. Tornadoes can travel hundreds of miles before they dissipate, although in the eastern part of the U.S., they rarely last that long.



http://www.mmem.spschools.org/grade5science/weather/tornadodiagram.html

Tornadoes occur across the eastern two-thirds of the continental U.S., but there are regions of much greater frequency. (Fortunately, we here in Southeastern Virginia are not among them.)

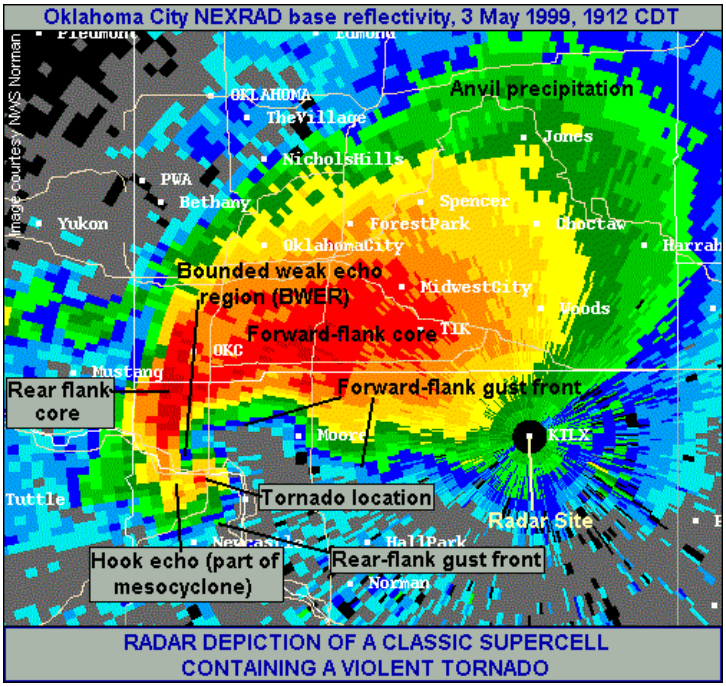


Graphic courtesy of Oklahoma Climatological Survey http://k12.ocs.ou.edu/teachers/graphics/TornadoFreq.gif

The most violent and destructive tornadoes in the U.S. usually occur over the plains states – Tornado Alley as it is called. These storms are associated with super-cell thunderstorms or tornadic supercells. Conditions in our part of the country are not favorable for supercell formation, but we do experience squall lines at the leading margin of large, rapidly moving cold fronts. Squall line thunderstorms – capable of producing **microburst downdrafts** – can be as destructive as supercells.

The "**hook echo**" in radar reflectivity imagery has been associated with tornado-producing thunderstorms since the 1950s. It is most often this radar signature that prompts tornado warnings from the National Severe Storms Laboratory and the National Weather Service.

Rarely, however, is the signature as classical or obvious as in this image. The bright red colors at the tornado location represent not rain or hail, but the aggregate signature of car parts, pieces of houses, shredded tree branches, dirt and other debris, hoisted thousands of feet skyward by the tornado vortex.



A Doppler radar image of a supercell, F-5 tornado

Major tornadoes leave a vivid swath of destruction.

See the highway overpass that lay in this tornado's path? More about it later…

http://www.spc.noaa.gov/faq/tornado/radscel.htm

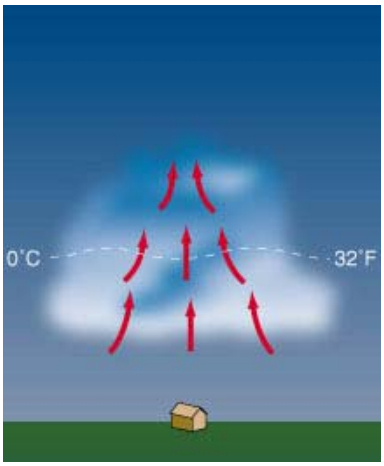
Tornadoes are progeny of severe thunderstorms.

To understand tornadoes, we need to know a few things about **thunderstorms**.

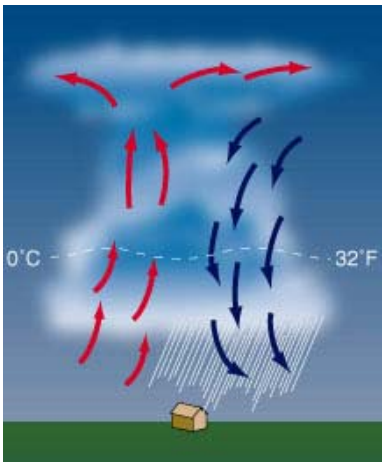
Every thunderstorm requires:

- **Moisture** - to form clouds and rain.
- **Unstable Air** - relatively warm air that can rise rapidly.
- **Lift** - fronts, sea breezes, and mountains are capable of lifting air to help form thunderstorms.

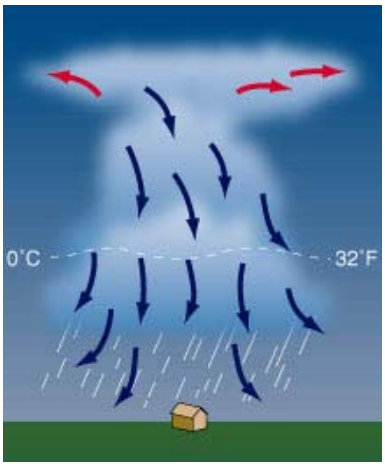
All thunderstorms go through stages of life.



Cumulus



Mature



Dissipating

Images are courtesy of Windows to the Universe, http://www.windows.ucar.edu

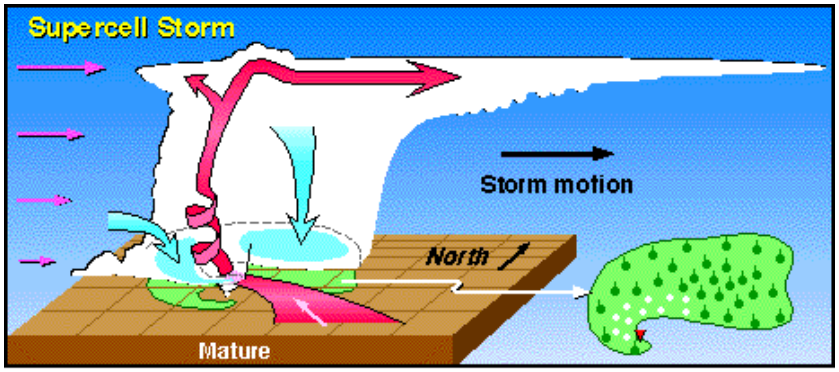
Severe thunderstorms

When conditions are favorable (collision of large air masses – cold/dry & warm/humid, for example), especially strong thunderstorms may form. They can last for hours, producing:

Flash Floods/Floods Severe Lightning Straight-line Winds Large Hail Tornadoes

As these thunderstorms develop, a change in wind direction, along with an increase of wind speed with increasing height, creates an invisible, horizontal spinning effect in the lower atmosphere. Rising air within the thunderstorm updraft tilts the rotating air from horizontal to vertical. The area of rotation, 2-6 miles wide, now extends through much of the storm. This rotating column of air, known as a funnel, extends from the cloud and grows downward toward the ground.

If the funnel touches the ground it becomes a tornado. Since the center of the funnel is a low pressure area, air rushes into the column and rises. The air is cooled as it rises, and water vapor condenses to form the familiar funnel-shaped cloud. As the rotating winds begin to pick up dirt and debris from the ground, the funnel will darken. The strongest tornadoes occur in supercell thunderstorms which can also produce large hail and strong downbursts.



Severe Weather Spotting

Cloud features help assess a thunderstorm's severity and its tornado potential. These include some characteristic features of the **cloud base**.

Perhaps the easiest low-level feature to identify is the **rain-free base**. As its name suggests, this is an area of smooth, flat cloud base beneath the main storm tower from which little or **no precipitation is falling**. The rain-free base is usually just to the rear (generally south or southwest) of the precipitation area. The rain-free base marks the main area of inflow where warm, moist air at low levels enters the storm. Some have called the rain-free base the "intake area" of the storm.

Lowering of the rain-free base and "accessory clouds," such as wall clouds, shelf clouds and roll clouds, mark important areas of the storm.

http://www.millville.org/Workshops_f/Rowe_Science/tornadoes_f/tornadoes-wack/spotterguide.html

Wall Clouds

A distinctive formation below thunderstorms, called a wall cloud, is strongly associated with tornado formation. If the wall cloud is rotating, the odds of a tornado increase. Tornado-spotter training emphasizes the ability to differentiate wall clouds from look-alikes. Except for Doppler radar, advance observation of a wall cloud is perhaps the most useful early warning of tornado formation.

Wall Clouds	Shelf Clouds
Suggest inflow/updraft	Suggest downdraft/outflow
Maintain position/outflow	Move away from rain
Slope upward away from precip. area	Slope downward away from precip. area

Shelf Clouds

Roll Cloud

Wall cloud - A wall cloud, a lowering of the cloud base underneath main storm updraft, forms in this thunderstorm. Tornadoes can form out of the wall clouds. Cyclonically curved bands are visible in the ambient cloud base – especially in front of the wall cloud (upper center). These bands spiraled from left to right; while scud formed near the tip of the rear tail cloud and moved right to left. This is classic wall cloud structure.

Once a wall cloud has been positively identified, the next challenge is to determine its tornado potential. There are four main characteristics usually observed with a tornadic wall cloud.

First, the wall cloud will be persistent. It may change its shape, but it will be there for 10-20 minutes before the tornado appears.

Second, the wall cloud will exhibit PERSISTENT rotation. Sometimes the rotation will be very visible and violent before the tornado develops.

Third, strong surface winds will blow in toward the wall cloud from the east or south east (inflow). Usually surface winds of 25-35 miles an hour are observed near tornadic wall clouds.

Fourth, the wall cloud will exhibit evidence of rapid vertical motion. Small cloud elements in or near the wall clouds will quickly rise up into the rain-free base. Not all tornadic wall clouds will have these characteristics (and some tornadoes do not form from wall clouds), but these four characteristics are good rules of thumb to follow.

Photos and text courtesy of University of Texas:
http://www.tsgc.utexas.edu/stars/tscloud.html

Tornado & Wall Cloud

Photo courtesy of NOAA:

http://www.spc.noaa.gov/faq/tornado/torscans.htm

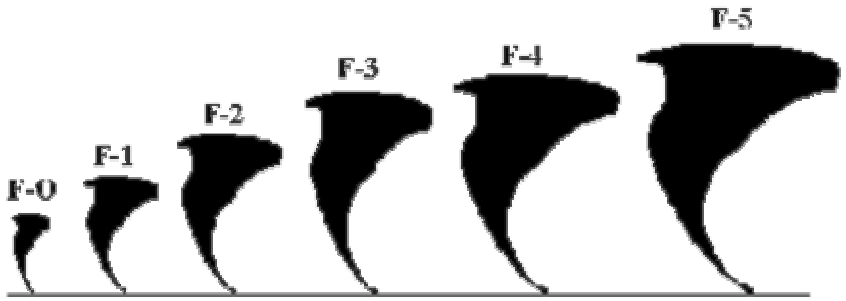
An "imposter." It's actually a non-rotating shelf cloud, but it fooled experienced storm-chasers.

Photo courtesy of NOAA: http://www.spc.noaa.gov/faq/tornado/notahose.htm

More Facts & A Few Myths about Tornadoes

Not much data exit on actual tornado wind velocities. When tornadoes pass over fixed meteorological instruments, they tend to destroy them. And – Hollywood notwithstanding – there is a scarcity of volunteers willing to dart into the tornado's certain path to position more robust equipment.

Tornado strength is measured by the "Fujita Scale." Named after its creator, Tetsuya Theodore Fujita, it categorizes tornado severity based on subjective, after-the-fact



evaluation of the damage observed, **not** recorded wind speeds. Wind speeds referred to in this scale are estimates that are intended to represent the observed damage. An F-5 tornado might be classified lower if it traveled over an unpopulated and sparsely vegetated area, leaving less damage than it did in the nearby town.

- **F-0:** 40-72 mph, chimney damage, tree branches broken
- **F-1**: 73-112 mph, mobile homes pushed off foundation or overturned
- **F-2:** 113-157 mph, considerable damage, mobile homes demolished, trees uprooted
- **F-3:** 158-205 mph, roofs and walls torn down, trains overturned, cars thrown
- **F-4:** 207-260 mph, well-constructed walls leveled
- **F-5:** 261-318 mph, homes lifted off foundation and carried considerable distances, autos thrown as far as 100 meters

Tornado Myths and Truths

MYTH	TRUTH
Areas near lakes, rivers, and mountains are safe from tornadoes.	No place is safe from tornadoes. A tornado near Yellowstone National Park left a path of destruction up and down a 10,000 foot mountain.
The low pressure with a tornado causes buildings to "explode" as the tornado passes overhead.	Violent winds and debris slamming into buildings cause most structural damage.
Windows should be opened before a tornado approaches to equalize pressure and minimize damage.	Leave the windows alone. The most important action is to immediately go to a safe shelter.
If you are driving and a tornado is sighted, you should turn and drive at right angles to the storm.	The best thing to do is to seek the best available shelter. Many people are injured or killed when remaining in their vehicles.
People caught in the open should seek shelter under highway overpasses.	Take shelter in a sturdy reinforced building if at all possible. Overpasses, ditches, and culverts may provide limited protection from a tornado, but your risk will be greatly reduced by moving inside a strong building.

Highway Overpasses as Tornado Shelters?

A really bad idea, say the experts. That famous video on TV? It showed some very lucky people. The eye missed them; they only experienced the inflow to the funnel. More commonly, people are killed or injured when they seek refuge under a bridge or overpass.

Remember the picture above of the damage path crossing the overpass? This bridge with girders, at 16th St. and Interstate 44 in Newcastle, OK, was where one person was killed by the Bridge Creek/Moore tornado of 3 May 1999. The tornado's winds sprayed red-clay mud upward and inward (from lower left); and the outlines of where people were crouched is clearly evident as gaps in the veneer of dried mud above the embankment. Several people were plastered with mud and small debris; and a woman was blown out from under the bridge, killed and dismembered. This tragic event illustrates just one of several grave dangers of seeking shelter under a bridge in a tornado.

http://www.spc.noaa.gov/faq/tornado/i44brdg.htm

So…

The weather-alert radios are going off. The TV screen scrawls are going non-stop. Severe thunderstorm warnings have been posted. Want to go outside to watch the approaching storm?

Think about this: **On average, lightning kills more people per year than tornadoes.** Strikes can occur many miles from the base of a thunderstorm, even without rain – and even with the sun shining! Listening for approaching thunder is a good idea – unless you are the target of the first flash. You can't dodge a lightning strike; and you will never see or hear the one which hits you. With that in mind, check out the NOAA lightning page and NSSL's lightning facts and safety page...and be better prepared.

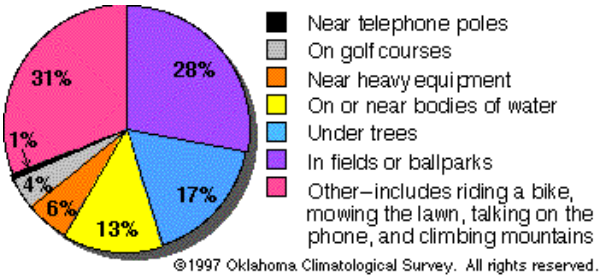
http://www.spc.noaa.gov/faq/tornado/oswalt.htm

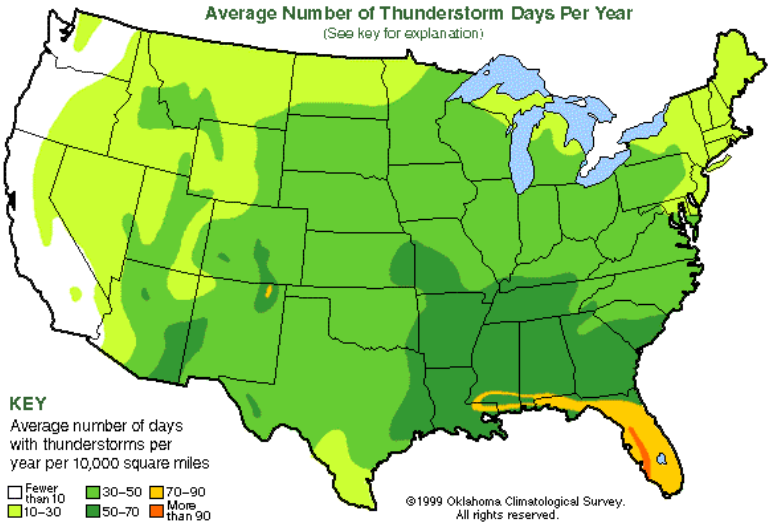
What are some myths concerning Lightning?

MYTH	FACT
If it is not raining, then there is no danger from lightning	Lightning often strikes outside of heavy rain and may occur as far as 10 miles away from any rainfall.
The rubber soles of shoes or rubber tires on a car will protect you from being struck by lightning	Rubber-soled shoes and rubber tires provide NO protection from lightning. However, the steel frame of a hard-topped vehicle provides increased protection if you are not touching metal. Although you may be injured if lightning strikes your car, you are much safer inside a vehicle than outside.
People struck by lightning carry an electrical charge and should not be touched	Lightning-strike victims carry no electrical charge and should be attended to immediately.
"Heat lightning" occurs after very hot summer days and poses no threat.	What is referred to as "heat lightning" is actually lightning from a thunderstorm too far away for thunder to be heard. However, the storm may be moving in your direction!
Lightning never strikes twice in the same spot.	The fact that an object was stuck once may indicate that it is a naturally attractive target.

http://www.nws.noaa.gov/om/brochures/ttl.pdf

Where do lightning injuries occur?





Pretty much everywhere in the U.S. except California. (They have an entirely different problem.)

More severe weather information resources for the truly fascinated:

NOAA's Techniques for Issuing Severe Thunderstorm & Tornado Warnings: http://www-das.uwyo.edu/~geerts/cwx/notes/chap09/sr185.htm

NOAA's Lightning Safety Website: http://www.lightningsafety.noaa.gov/

Q & A About Lightning: http://www.nssl.noaa.gov/edu/ltg/

The Weather Prediction.com: http://www.theweatherprediction.com/

Oklahoma Climatological Survey (U. of Oklahoma): http://www.ocs.ou.edu/outreach/

Storm Spotter's Guide, An illustrated guide to identifying severe storms: http://www.millville.org/Workshops_f/Rowe_Science/tornadoes_f/tornadoes-wack/spotterguide.html